

AMS-02 E-CRATE on USS

Structural Analysis

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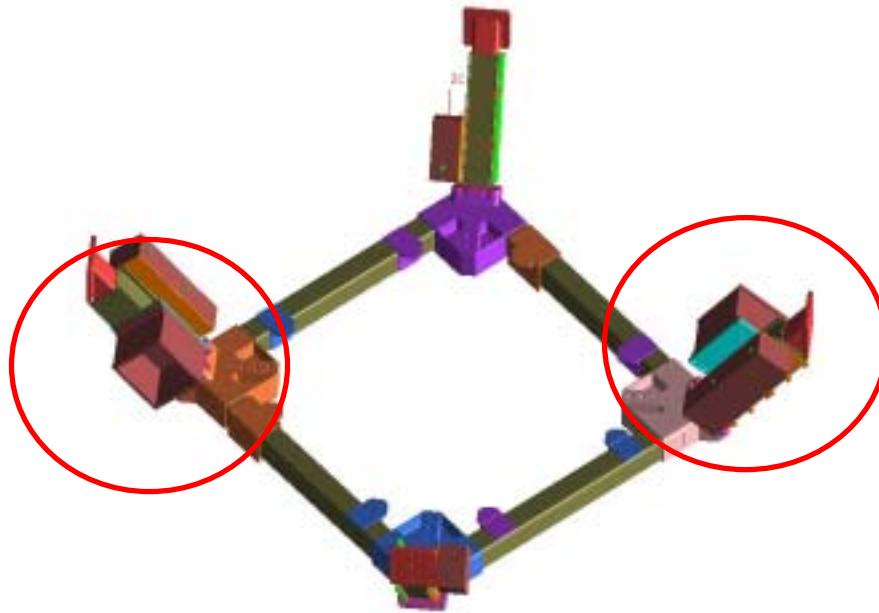
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INTRODUCTION

Next slides show the structural analysis of the **E-CRATES** mounted directly on the **USS** of the **AMS-02**.

This analysis is compliant with S.V.P. (JSC-28792 rev. C) requirements



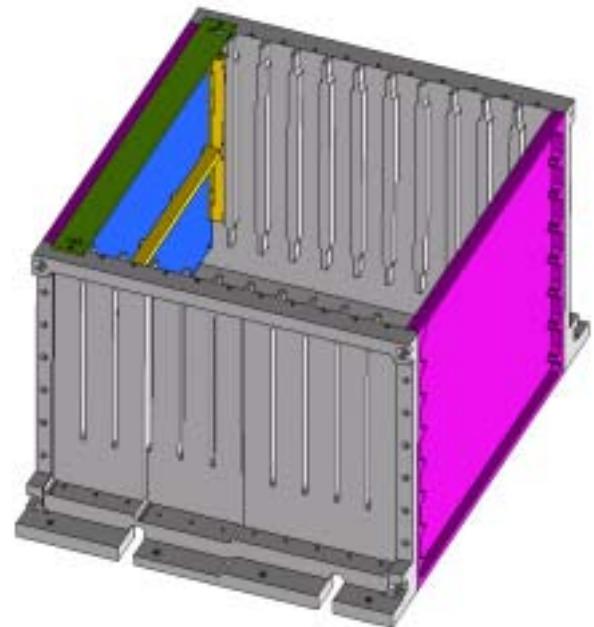
E-CRATES DESCRIPTION

Used materials:

- AL 7075 T7351 for the whole structure
- FR4 for PCB boards and motherboard

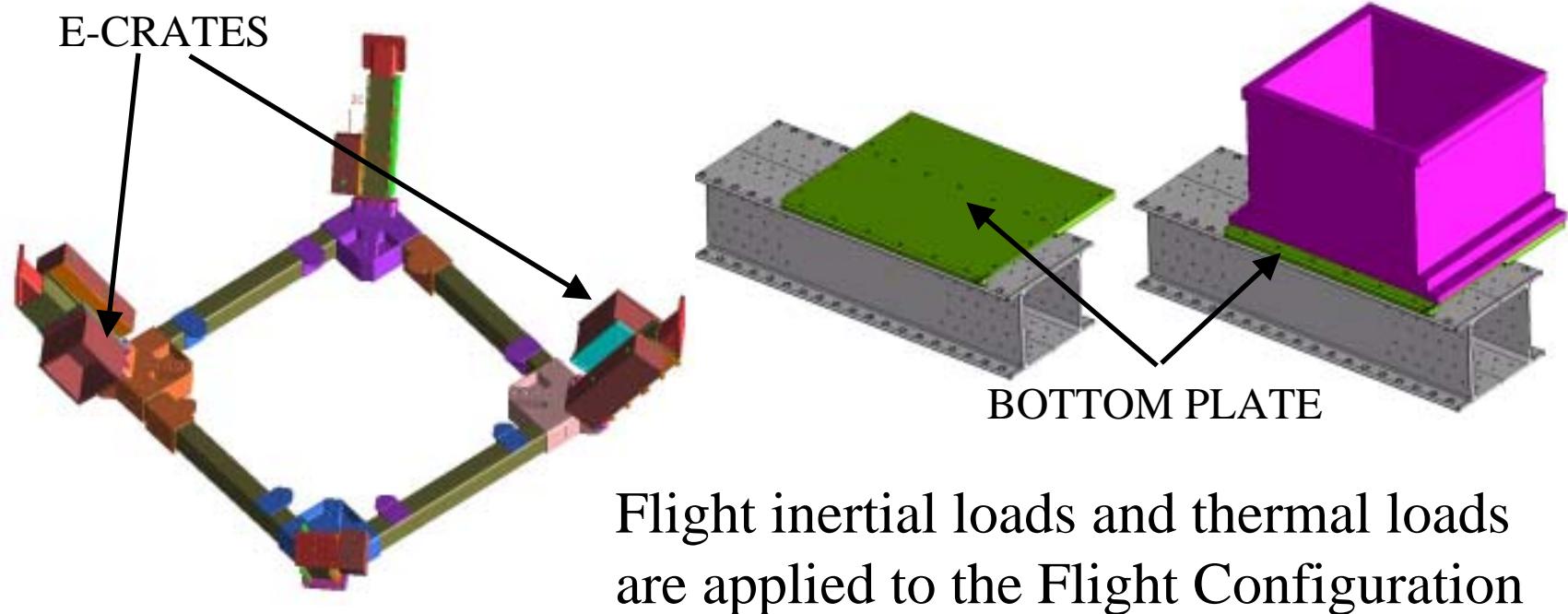
Two different configurations are analysed:

- Flight Configuration USS mounted
- test configuration, units mounted on shaker interface fixture for Vibration testing (option)

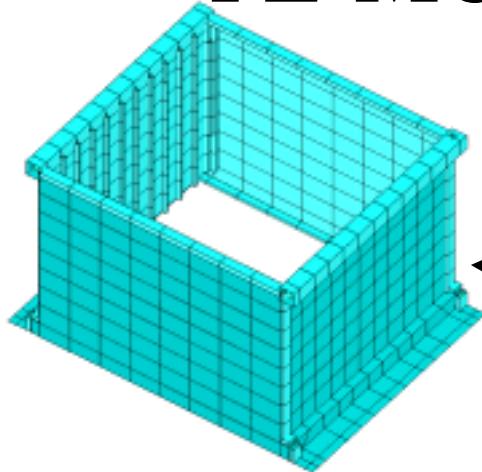


E-CRATES CONFIGURATIONS

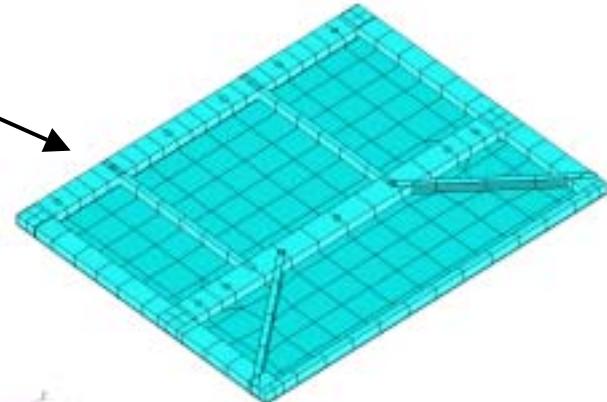
Two E-CRATES are accommodated onto the USS



FE-MODEL DESCRIPTION

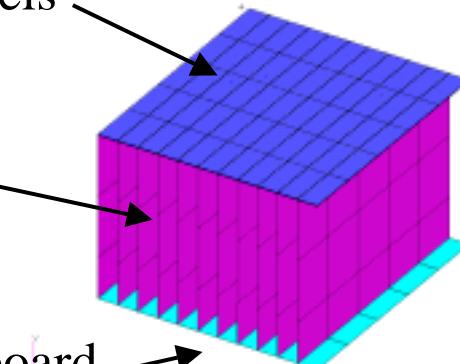


Lateral walls



Bottom plate

Boards front panels

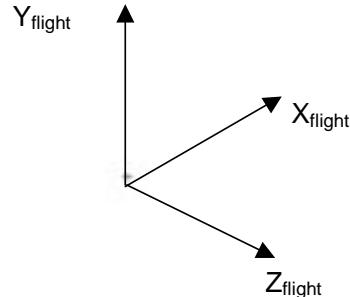
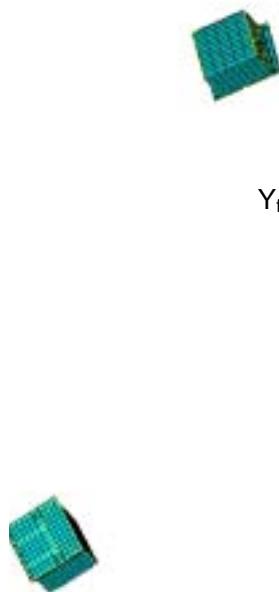


PCB boards

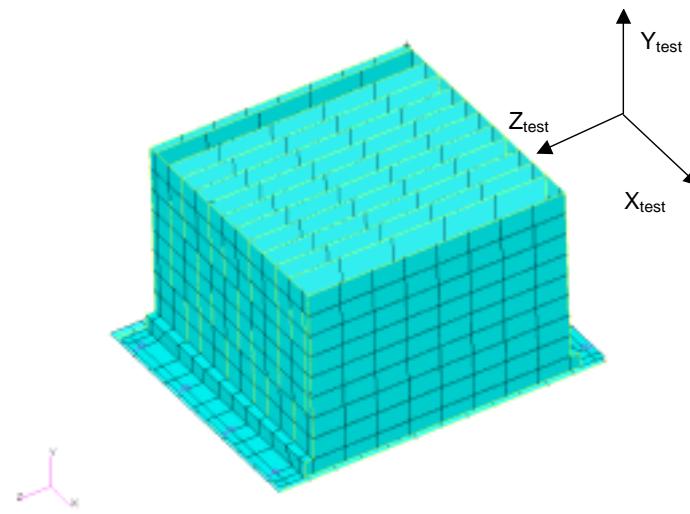
Motherboard

| MODEL SUMMARY | |
|-----------------|-----|
| GRID POINTS | 957 |
| CBAR ELEMENTS | 436 |
| CBEAM ELEMENTS | 32 |
| CQUAD4 ELEMENTS | 882 |
| CTRIA3 ELEMENTS | 30 |
| RBE2 ELEMENTS | 8 |

FE-MODEL DESCRIPTION



Flight Configuration reference
coordinate system
(AMS02 coordinate system)



Test Configuration reference
coordinate system

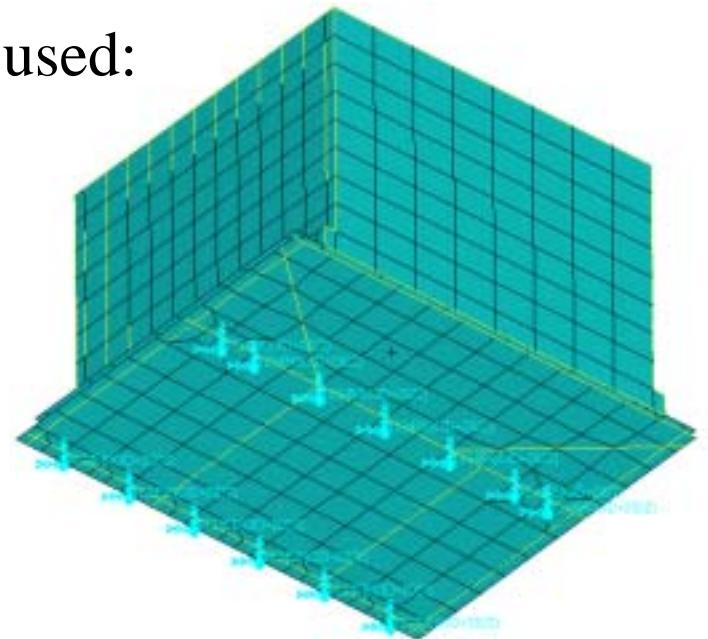
FE-MODEL DESCRIPTION

| E-CRATE MASS BUDGET | | | | | | | |
|----------------------|-------------------|-----------|-----------|------|------------|----------|----------|
| compiled: 25/02/2004 | | | | | | | |
| SYSTEM | SUBSYSTEM | COMPONENT | MASS [Kg] | QTTY | TOTAL MASS | CONT [%] | FEM MASS |
| E-CRATE | STRUCTURE | STRUCTURE | 3.502 | 1 | 3.502 | 10% | 3.852 |
| | | | | | 3.502 | | 3.852 |
| | ELECTRONIC BOARDS | EDR2 | 0.350 | 6 | 2.100 | 10% | 2.310 |
| | | EPSFE | 0.350 | 3 | 1.050 | 10% | 1.155 |
| | | JINF | 0.350 | 1 | 0.350 | 10% | 0.385 |
| | | ETRG | 0.350 | 1 | 0.350 | 10% | 0.385 |
| | | EBP | 0.400 | 1 | 0.400 | 10% | 0.440 |
| | | | | | 4.250 | | 4.675 |
| | | | | | 7.752 | | 8.5272 |

Note: FEM contingency applied

FE-MODEL DESCRIPTION

HARDMOUNTED interface to USS is used:
6 DoF constrained in 13 nodes
at the end of beams representing bolts



STRUCTURAL REQUIREMENTS

SVP structural requirements:

- SF used defined in applicable SVP
- All the MoS of the structure positive, under applicable design loads:
 - Flight inertial loads from SVP and
 - Random vibration test loads from SVP
 - Thermal loads from AMS02 thermal analysis at system level
- The first natural frequency (with effective mass > 5%) greater than 50Hz

Safety factors:

Yield = 1.25

Ultimate = 2

MoS definition:

$$\text{MoS} = \frac{\text{A}}{\text{SF} \cdot \text{B}} - 1.0$$

A - allowable

B - actual value

SF - applicable safety factor

AMS 02 –Thermal Control

System Design



LOAD CASES

Flight Configuration load cases:

| LOAD CASE | DESCRIPTION | X _{flight} | Y _{flight} | Z _{flight} |
|-----------|---------------------|---------------------|---------------------|---------------------|
| LC1-8 | Design flight loads | ± 40 g | ± 10 g | ± 10 g |
| LC9-16 | Design flight loads | ± 10 g | ± 40 g | ± 10 g |
| LC17-24 | Design flight loads | ± 10 g | ± 10 g | ± 40 g |

↙ SVP
(MASS<20pounds)

Test Configuration load cases (RVLF with mass participation formula) :

| LOAD CASE | DESCRIPTION | X _{test} | Y _{test} | Z _{test} |
|-----------|-------------------|-------------------|-------------------|-------------------|
| LC25-32 | Design test loads | ± 20 g | ± 2 g | ± 2 g |
| LC33-40 | Design test loads | ± 4.1 g | ± 41 g | ± 4.1 g |
| LC41-48 | Design test loads | ± 2.5 g | ± 2.5 g | ± 25 g |

↙ SVP
RVT (MWL)

Thermal analysis load cases:

| LOAD CASE | DESCRIPTION | TOP | SIDE 2 | SIDE 3 | SIDE 4 | SIDE 5 | USS | ELECTRONIC BOARDS |
|-----------|--------------------|-------|--------|--------|--------|--------|-------|-------------------|
| LC49 | Thermal loads (°C) | -12.3 | -15.7 | -12.4 | -12.4 | -12.0 | -16.3 | -7.9 |
| LC50 | Thermal loads (°C) | 47.9 | 31.6 | 44.4 | 50.2 | 46.7 | 39.6 | 49.0 |

↙ AMS02 system thermal analysis

MODAL ANALYSIS (1/2)

First 10 normal frequencies

| Mode | Freq [Hz] |
|------|-----------|
| 1 | 103.4 |
| 2 | 112.9 |
| 3 | 113.1 |
| 4 | 114.3 |
| 5 | 115.1 |
| 6 | 115.9 |
| 7 | 116.5 |
| 8 | 117.1 |
| 9 | 117.4 |
| 10 | 117.7 |

Modes with associated effective mass greater than 5% in Test Configuration coordinate system

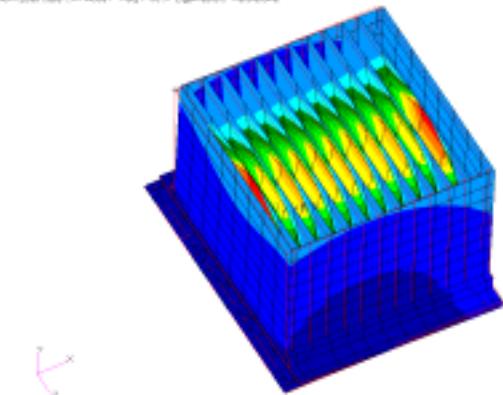
| Mode | Freq [Hz] | % of total mass Nx_{test} | % of total mass Ny_{test} | % of total mass Nz_{test} |
|------|-----------|-----------------------------|-----------------------------|-----------------------------|
| 1 | 103.37 | 45.86% | <1% | <1% |
| 26 | 280.52 | <1% | <1% | 35.65% |
| 27 | 293.14 | <1% | 81.75% | <1% |
| 54 | 532.39 | <1% | <1% | 12.16% |
| 56 | 563.10 | <1% | <1% | 11.18% |
| 57 | 566.42 | <1% | <1% | 18.12% |
| 112 | 1048.33 | 5.91% | <1% | <1% |
| 127 | 1280.71 | 5.43% | <1% | <1% |
| 128 | 1292.74 | 11.84% | <1% | <1% |

AMS 02 –Thermal Control System Design



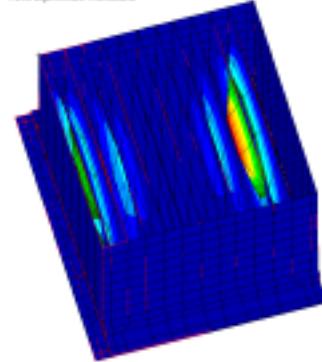
MODAL ANALYSIS (2/2)

MSC.Patent 2003-07-Pat-04 11-2003
ProjektLaser/Caser 1, 40 Mode 1. Freq = 163.27 Eigenmodes, Transient(0.0-1000) (Aero)
Dreh/Lossl/Transl 1, 40 Mode 1. Freq = 163.27 Eigenmodes, Transient



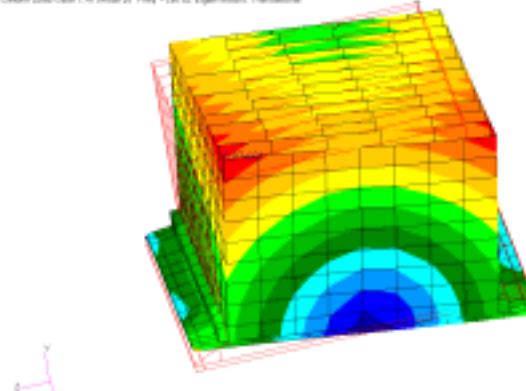
1st Mode

MSC.Patent 2003-07-Pat-04 11-2003
ProjektLaser/Caser 1, 40 Mode 2. Freq = 163.27 Eigenmodes, Transient(0.0-1000) (Aero)
Dreh/Lossl/Transl 1, 40 Mode 2. Freq = 163.27 Eigenmodes, Transient



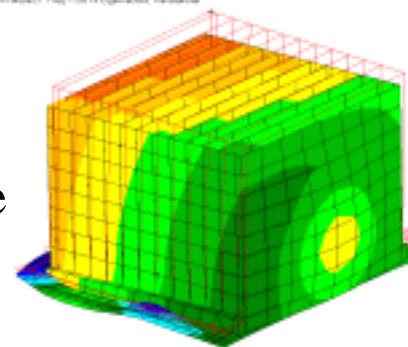
2nd Mode

MSC.Patent 2003-07-Pat-04 11-2003
ProjektLaser/Caser 1, 40 Mode 26. Freq = 260.0 Eigenmodes, Transient(0.0-1000) (Aero)
Dreh/Lossl/Transl 1, 40 Mode 26. Freq = 260.0 Eigenmodes, Transient



26th Mode

MSC.Patent 2003-07-Pat-04 11-2003
ProjektLaser/Caser 1, 40 Mode 27. Freq = 261.0 Eigenmodes, Transient(0.0-1000) (Aero)
Dreh/Lossl/Transl 1, 40 Mode 27. Freq = 261.0 Eigenmodes, Transient



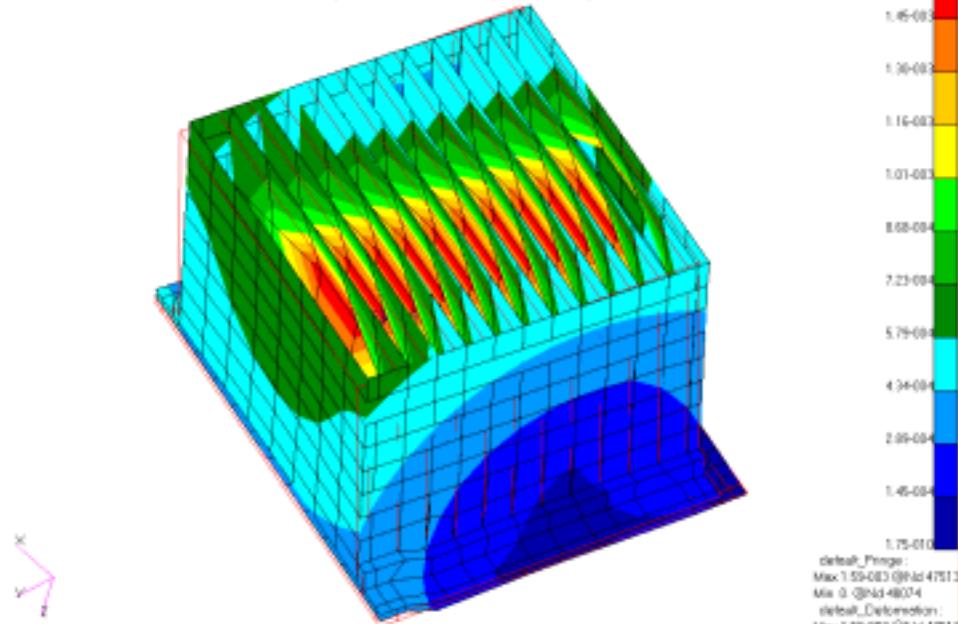
27th Mode

STATIC ANALYSIS (1/3)

| MARGINS OF SAFETY FOR STRENGHT FAILURE (STRESS) | | | | | | | |
|---|------------------|----------------------|------------------|--------------------|------------------|-------------------------|------------------|
| | | Flight Configuration | | Test Configuration | | Thermo-elastic analysis | |
| ITEM | MATERIAL | MoS _Y | MoS _U | MoS _Y | MoS _U | MoS _Y | MoS _U |
| Lateral walls (plate) | AL 7075 T7351 | 8.775 | 6.185 | 19.960 | 14.400 | 9.286 | 6.561 |
| Lateral walls (bar) | AL 7075 T7351 | 3.808 | 2.534 | 6.687 | 4.648 | 5.062 | 3.456 |
| Bottom plate (plate) | AL 7075 T7351 | 4.952 | 3.375 | 6.668 | 4.634 | 29.433 | 21.371 |
| Bottom plate (bar) | AL 7075 T7351 | 2.178 | 1.336 | 3.367 | 2.208 | 26.589 | 19.280 |
| Electronic mechanical structure | AL 7075 T7351 | 12.357 | 8.819 | 27.324 | 19.811 | 6.935 | 4.833 |
| Electronic | FR4 | NA | 11.658 | NA | 22.256 | NA | 9.417 |

STATIC ANALYSIS (2/3)

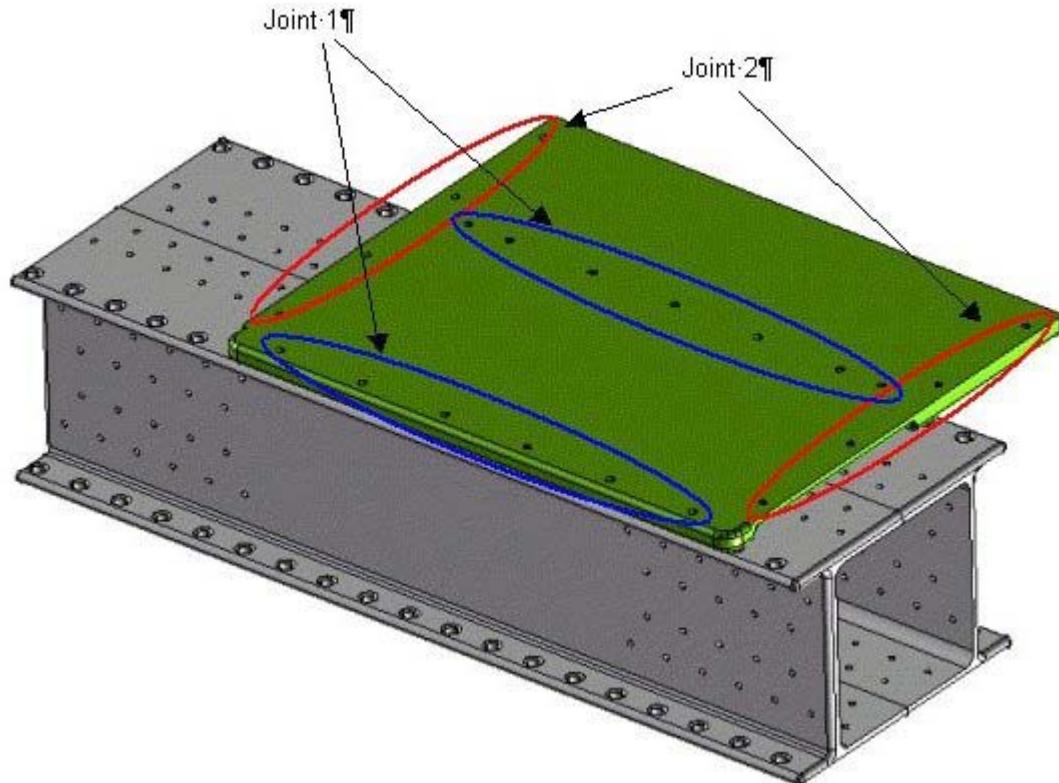
MSC.Patran 2003 v23-Feb-04145817
FreigeSC1: UN1X40,0 Y18,0 Z18,0 At Static Subcase, Displacements, Translational - Magnitude, (NON-LAYERED)
Defomi SC1: UN1X40,0 Y18,0 Z18,0 At Static Subcase, Displacements, Translational, (NON-LAYERED)



Maximum displacement:
1.59 mm on the Electronic
Boards for load case 17

STATIC ANALYSIS (3/3)

| MoS Type | MoS Value | Joint |
|-------------|-----------|-------|
| MoS sep | 0.66 | 1 |
| MoS combU | 0.386 | 2 |
| MoS brY | 6.80 | 2 |
| MoS brU | 4.82 | 2 |
| MoS lug t Y | 12.16 | 2 |
| MoS lug t U | 8.86 | 2 |
| MoS lug s Y | 4.16 | 2 |
| MoS lug s U | 4.59 | 2 |



CONCLUSIONS

Analyses show the E-CRATE compliance with the structural requirements:

- The 1st natural frequency is 103.4 Hz (requirements >50 Hz)
- All MoS are positive for all applied loads:
 - for the stress verification the minimum MoS is 1.336, (ultimate stress on bottom plate ribs in Flight Configuration)
 - for joints verification the minimum MoS is 0.386, (combined ultimate tensile-shear load on bolt on Joint 2 in Flight Configuration)